Critical analysis of diagnostic tools for the temporomandibular joint

Krytyczna analiza narzędzi diagnostycznych stawu skroniowo-żuchwowego

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A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

Abstract

The prevalence of temporomandibular disorder (TMD) in the general population is difficult to identify. Depending on the source, values range from 3% to 48.9%. These large discrepancies occur because of two main reasons. The first one is connected with the evolution of the definition and diagnostic criteria of TMD, while the second one concerns the use of different diagnostic tools, protocols, etc. Temporomandibular joint (TMJ) diagnosis is both quantitative and qualitative.

Quantitative measurements used in the field of scientific research are highly accurate motion capture systems used for kinematic analysis, while an electronic caliper is applied in a clinical setting. MRI seems optimal in TMJ disc and its dysfunction imaging. In more difficult cases, ultrasound imaging can be used. On the other hand, CT is the best examination for joint imaging.

In recent years, qualitative measurements have been dominated by vibroarthrography (VAG), which shows good diagnostic value.

Research Diagnostic Criteria for Temporomandibular Joint Disorders (RDC/TMD) is the most complex systematized diagnostic tool for TMD. The proposed procedure allows us to differentiate a real TMJ dysfunction from other systemic problems that can manifest themselves in this region of TMJ, such as depression, chronic pain or psychosomatic disorders. RDC/TMD are constantly evaluated and modified in terms of their diagnostic or clinical value by experts associated in the International RDC-TMD Consortium. Currently it is the best tool available for TMD diagnostics. The RDC/TMD questionnaire was translated into Polish, culturally adapted and officially approved by the Consortium. The aim of the study is to review selected TMD diagnostic tools and to assess their diagnostic value.

Key words: **TMD, TMJ, temporomandibular disorders, temporomandibular joint, RDC-TMD**

Streszczenie

Występowanie zaburzeń skroniowo-żuchwowych (TMD) w ogólnej populacji jest trudne do określenia. W zależności od źródła wartości wahają się w przedziale 3-48,9%. Tak duże rozbieżności wynikają z dwóch powodów: pierwszy jest związany z ewolucją definicji TMD oraz kryteriów kwalifikacji pacjentów, natomiast drugi dotyczy korzystania z różnych narzędzi badawczych.

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The research was financed from the athors` own resources
Badanie sfinansowane ze środków własnych autora

Diagnostyka stawu skroniowo-żuchwowego odbywa się przede wszystkim na dwóch poziomach – ilościowym i jakościowym. Dodatkową pomocą w rozpoznaniu są badania obrazowe oraz kwestionariusze czy badania ankietowe.

Wśród badań ilościowych wykorzystywanych na potrzeby badań naukowych najbardziej dokładnymi narzędziami są systemy analizy kinematycznej, natomiast do pomiarów klinicznych suwmiarka elektroniczna. Badania jakościowe zostały zdominowane w ostatnich latach przez wibroartrografię, która wykazuje dobrą wartość diagnostyczną.

Badanie rezonansem magnetycznym jest optymalne do obrazowania krążka stawowego i jego dysfunkcji. W trudniejszych przypadkach wskazane jest wspomaganie diagnostyki badaniem ultrasonograficznym. Z drugiej strony do obrazowania stawu należy korzystać z tomografii komputerowej.

Najbardziej kompleksowym i usystematyzowanym kwestionariuszem jest RDC-TMD (ang. Randomized Diagnostic Criteria for Temporomandibular Joint Disorders), czyli Badawcze Kryteria Diagnostyczne Zaburzeń Czynnościowych Układu Ruchowego Narządu Żucia – BKD/ZCURNŻ. Procedura pozwala zróżnicować rzeczywiste zaburzenia skroniowo-żuchwowe od innych problemów ogólnych, które mogą manifestować się w okolicy stawu skroniowo-żuchwowego, takich jak: depresja, ból przewlekły czy choroby psychosomatyczne.

BKD są systematycznie poddawane ocenie oraz modyfikacji pod względem wartości diagnostycznej czy klinicznej dzięki pracy ekspertów zrzeszonych w Konsorcjum RDC-TMD. Obecnie jest to najlepsze narzędzie badawcze do diagnostyki TMD. Kwestionariusz został przełożony na język polski, zaadaptowany kulturowo oraz zatwierdzony, jako oficjalny.

Celem niniejszej pracy jest przegląd wybranych narzędzi badawczych dedykowanych TMD, oraz ocena ich wartości diagnostycznej.

Słowa kluczowe: **TMD, TMJ, zaburzenia skroniowo-żuchwowe, staw skroniowo-żuchwowy, RDC-TMD**

Introduction

Temporomandibular disorder (TMD) is a term referring to pathologies in which pain in the temporomandibular joint (TMJ) area is a dominant symptom. The main causes of these complaints are linked with a real TMJ problem, pathology of soft tissues surrounding it (a disc or ligaments) and/or muscles of mastication. Other symptoms reported by patients may include joint crepitus, loss of mandible range of motion or an asymmetry in jaw movement [1]. Additionally, psychosocial factors can contribute to pain occurrence in this area [2].

All the above-mentioned symptoms may make activities such as speaking, chewing or hygiene maintenance difficult or even impossible to perform, not to mention an aesthetic defect. These factors can result in patients withdrawing from social or professional activities, thus decreasing their comfort levels and quality of life.

Epidemiology

Data regarding the prevalence of TMD fall within a very wide range. Different diagnostic tools used by researchers, inclusion criteria, age of participants or an influence of coexisting diseases are recognized as essential factors [3].

The first reference to the frequency of occurrence of TMD was made in the early 1970s [4,5]. Currently estimates fall within the range of between 20 and 25% of the general population [4,5]..

Further studies with the development of specific diagnostic tools have resulted in reported occurrence rates at 5% [4], 3–4% [6], 6–7% [5], 2–4% [3], 8.4% [7] or 15.6–16.2% [8] for patients who required an intervention due to the intensity of their symptoms.

Two studies describing native populations can be found in the Polish literature. Despite the fact that authors used the same diagnostic criteria, they showed different results, i.e. 48.9% [9] and 26.5% [10].

The development and spread of the RDC/TMD questionnaire has allowed researchers to compare their results, which directly influenced epidemiology data update both for the eneral population and patients with TMD symptoms.

The research revealed disc pathology in 11.4% [11] in the general population and 41.1% in TMD patients. Other studies showed TMJ disorders in 56.4% of the general population, 42% of whom had a disc problem [12]. In general, the literature shows a higher prevalence of TMD in women than men (a proportion of 3-4:1) [10,11,13,14]. There is a common agreement among researchers that the peak period of TMD occurs between the ages of 20 to 40 [15,16].

An interesting phenomenon of pathology coexistence was observed in the literature, i.e. disc and muscle or muscle and joint disorders. The rate of its occurrence ranged from 26.5% [10] to 38% [9] or even 64.3% of tested population [15].

Aim

The aim of the current study is to review selected tools used for diagnosing TMD and to assess their diagnostic value as well as to present the RDC/TMD questionnaire as the most complex tool for both scientific research and clinical practice.

Overview of diagnostic tools for temporomandibular joint

Due to a wide spectrum of symptoms (i.e. joint pain, muscle pain, limitation of the range of motion, asymmetry of movement, crepitus) resulting from TMD, many diagnostic tools have been developed over the years. They can be classified into the following categories:

- quantitative tools,
- qualitative tools,
- imaging examinations (MRI, CT, etc.),
- questionnaires and surveys.

Quantitative tools

Methods measuring the range of motion (ROM) of the TMJ play a primary role among quantitative tools because they can depict the trajectory of the mandible and describe its kinematics. These devices can be divided into two groups – simple devices used in a clinical setting and more advanced tools designed for scientific research. Simple methods include rulers (e.g. TheraBite® ruler) [17] or calipers (manual or electronic ones) [18,19]. The fact that they are quick and easy to use is a definite advantage especially in clinical practice when measuring both abduction and lateral mandible movements (mediotrusion and laterotrusion) [18,19]. Good validity of these procedures has been demonstrated in the literature [18].

More recent advanced devices for TMJ ROM measurements use technology that depicts a three-dimensional trajectory of mandible movements, which allows us to draw the Posselt diagram. Motion capture devices that have these features include: WinJawZebris®, Virtual Facebow®, KaVoARCUSdigma®, or Condylocomp® LR3. Because of their versatility and accuracy of 0.1mm [21] these devices are widely used in scientific research [22-28]. The main hindrance is a high purchase and operating cost.

Another aspect of TMJ diagnostics is pain measurement. Subjective levels of pain are most often tested with Visual Analogue Scale (VAS) or Numeric Pain Rating Scale (NRS) [18,29].

Although algometry is considered to be an objective method, it was not used very often [30,31].

Qualitative tools

Assessment of joint crepitus occurrence and intensity was based on history, palpation and auscultation with a stethoscope [32]. Research evaluating those two methods in the context of disc disorders detection showed poor reliability and high percentage of false positive results [33].

Based on the aforementioned results, researchers sought alternative tools for obkectively evaluating crepitus, thus the introduction of vibroarthrography (VAG).

VAG is a qualitative method used for all synovial joints. It is based on vibroacoustic signal registration, generated by a relative movement of bones within the joint. So far it has been demonstrated that hyaline cartilage present in healthy joints has the ability to minimize the level of friction expressed by the coefficient of kinetic friction (~0.002–0.004). The described phenomenon ensures optimal quality of movement and low vibroacoustic signal emission. Any changes compromising the biomechanical environment inside the joint lead to deterioration in its arthrokinematics (i.e. joint play) manifested in magnifying signal intensity.

Joint Vibration Analysis (JVA) together with compatible software (BioPAK Measurement System, Bioresearch Inc., Milwaukee, USA) is the most common vibroacoustic device used for TMJ [33,35-39].

When analyzing the issue of measurement and registration repeatability, it has to be emphasized that contrary results have been published over the years [33,36,38-40].

Mier [33] indicated high subjectivity of vibroacoustic signal analysis as a direct cause of poor reliability among examiners. Furthermore, he showed a trend in the field of interest where many authors described technologies of signal recording; however, only one paper assessed VAG accuracy, while none of them rated their diagnostic value.

On the other hand, Zhang et al. [36] and Bakalczuk et al. [38] clearly showed VAG reliability to be good and excellent based on Intraclass Correlation Coefficient (ICC) – 0.75 and 0.738–0.907, respectively. The authors agreed on the need for further studies regarding diagnostic value of VAG and identification of characteristic waveforms for different subgroups of TMD patients.

Sharma et al. [39] published a systematic review which analyzed diagnostic value of JVA device in the context of TMJ pathologies detection. Most of the fifteen papers included in the review presented methodology limitations which prevented the authors from demonstrating strong enough evidence about JVA as a reliable diagnostic tool.

In another study, Sharma et al. [40] avoided the methodological mistakes identifies in their 2013 paper. The researchers obtained excellent reliability and marked JVA's diagnostic validity as high. They also proposed a composite score, which can be used to discriminate between normal and displaced disc position.

Imaging techniques

The selection of imaging types is mostly based on the potentially problematic structure. Recommendations for imaging are grouped by the following pathologies [41,42,43,44]:

- disc – MRI, USG, arthrography
- joint (arthritis or arthrosis) – CT, X-ray (dental panoramic radiograph).

The international RDC-TMD Consortium proposed interpretation guidelines for both unification purposes and also as an attempt to objectify the clinical reasoning process.

The findings of numerous studies have demonstrated that CT is the best tool for joint imaging (κ=0.71), whereas radiography was the poorest technique (κ=0.16) [41]. MRI is the best method for disc pathologies detection (κ=0.78–0.94) [41], which has been confirmed by a number of other studies [42,43,44].

Further studies showed the necessity for further evaluation and update of these guidelines (especially for the disc) regarding their influence on the pathology, diagnostic value and the cost of the procedure [45].

Ultrasound (US) has been shown to be useful as a supplemental examination especially in non-standard cases. Its validity and specificity is considered as good to excellent. Dynamic examination performance is its biggest advantage [46].

Strøm et al. [47] presented a similar conclusion regarding US as a supplemental method, claiming that the obtained results cannot be treated as decisive when excluding disc pathology compared to MRI.

Questionnaires

Quality of life (QOL) issues can be tested on three levels – general, characteristic of the disease and characteristic of the dysfunctional organ.

The literature shows a relatively small number of questionnaires measuring QOL on the general level. The Oral Health Related Quality of Life (OHRQoL) is the most commonly used questionnaire regarding oral cavity health in TMD population. The authors demonstrated that TMD patients suffered from lower QOL significantly more often than their controlled peers [48,49,50,51].

According to the World Health Organization (WHO), health is defined as a state of complete physical, mental and social well being and not merely the absence of disease or infirmity. OHRQoL measures the influence of oral health on the aforementioned aspects of health in general.

Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is an example of a questionnaire targeted at specific diseases i.e. temporomandibular disorders. The classification was proposed by the International RDC-TMD Consortium for the needs of scientific research in dentistry (International Association for Dental Research). The role of RDC/TMD is to recognize patient's symptoms and assign them to one of two axis (groups of pathologies). RDC/TMD questionnaire will be described in more detail later in this paper.

Jaw Functional Limitation Scale (JFLS) [52,53] with its two versions (8 and 20 items) as well as Mandibular Function Impairment Questionnaire (MFIQ) [54] are examples of organ-specific questionnaires.

JFLS-20 consists of 20 questions regarding three groups of activities – chewing, range of motion in the sagittal plane and verbal/emotional expression [53,55]. There is no official translation nor cultural adaptation of this tool in Poland.

MFIQ is made up of 17 questions assessing subjective perception of the effects of mandible dysfunction on such activities as speech, food and drink intake, laughing or yawning. The patient's

task is to mark a level of difficulty on a five-step scale, where the total score indicates severity of dysfunction from severe, through moderate to low.

Chinese and Portuguese authors who translated and culturally adapted MFIQ reported its diagnostic value as good and excellent [56,57]. As in the case of JFLS–20, official translation or cultural adaptation does not exist in Poland.

Less frequently used questionnaires are as follows: Fonseca's Questionnaire, Helkimo Index, Symptom Intensity Scale (SIS) or TMD Disability Index (Steigerwaldi Maher). Most of them have been replaced by RDC/TMD, which is the most complex and researched protocol available for TMD.

Research Diagnostic Criteria for Temporomandibular Joint Disorders (RDC/TMD)

Nowadays, RDC/TMD is the most widely used questionnaire in the field of scientific research and clinical practice. The foundations were set by Dworkin [58] within the International RDC-TMD Consortium. Over time, the criteria were supplemented and refined to form the latest version published in 2014 by Schiffman et al. [2] with later commentaries (Michelotti et al. 2016). At that time, the name was changed into Diagnostic Criteria for Temporomandibular Joint Disorders (DC–TMD).

DC/TMD divides pathologies into two axes. Axis I represents real TMJ and periarticular tissue disorders concerning muscles of mastication (myofascial), a disc and the joint itself. Each axis is divided into subcategories where pathologies are listed. Axis II represents patients experiencing pain or discomfort in the head, neck or TMJ area, whereas the cause of their symptoms is not directly linked with this region. In general, their symptoms occur due to chronic pain or depression. DC/TMD division is presented below [2].

Axis I
- muscle disorders:
  - Ia – myofascial pain,
  - Ib – myofascial pain with limited opening,
- disc displacement:
  - IIa – disc displacement without reduction,
  - IIb – disc displacement without reduction with limited mouth opening,
  - IIc – disc displacement without reduction, without limited opening,
- other joint conditions:
  - IIIa – arthralgia,
  - IIIb – osteoarthritis,
  - IIIc – osteoarthrosis.

Axis II
- psychological dimension of pain, including pain intensity, pain-related disability, and the presence of depression and non-specific symptoms.

The DC/TMD questionnaire is now the most commonly used diagnostic tool. The International RDC-TMD Consortium officially accepted, released and shared translations to native languages and cultural adaptations, which is an invaluable advantage. According to the organization's website, DC/TMD questionnaire is available in more than thirty languages, including a Polish version prepared by Osiewicz et al. [9,59].

The questionnaire consists of three parts [10]:
- administrative (history questionnaire, clinical examination form) – 31 questions;
- clinical examination specifications (instructions and verbal directives for the patient);
- scoring (algorithms for the evaluation of axis I and II).

Performing the examination according to the procedure makes it possible to classify the patient's symptoms to one or more groups (pathology coexistence) using provided algorithms. Since the protocol is unified, results obtained by different research centers can be compared.

The International RDC-TMD Consortium is responsible for constant development of the questionnaire both in the field of substantive area as well as practical use in clinical conditions. DC/TMD is evaluated during annual workgroup's meetings and panels of experts who report their suggestions and findings for future updates.

General findings from the latest meeting [45] showed the lack of correlations between TMJ's condition and image and the level of pain, dysfunction and disability. The report also consisted of specific conclusions regarding the disc. The authors presented a 9-item list of disc pathologies with a disclaimer that diagnostic values were not shown at all for four of them, and the other five

did not reach satisfactory levels of validity and specificity.

In connection with the above, a necessity for new guidelines (normative values and new criteria of assessing a diagnostic value for specific pathologies) was indicated. In addition, cost-effectiveness needs to be evaluated.

The main emphasis in therapy was put on the increase in effectiveness in terms of reducing the impact of the disease or delaying its progress [45].

Assessment of DC/TMD diagnostic value was first studied by Look et al. [60]. The authors analyzed axis I pathologies only (myofascial disorders, disc displacement and joint dysfunction). Kappa score for disc displacement detection varied from poor to good depending on the pathology (IIa – κ=0.51 good, IIb/IIc – κ=0.13–0.43 poor). Results show that using the questionnaire by itself may lead to classification errors.

In the case of the International RDC-TMD Consortium guidelines [2], which promote MRI examination as a necessary stage of a diagnostic procedure, Kappa score for the disc is 0.84. Researchers developed statistics for a joined procedure of DC/TMD protocol and MRI of the disc, where the lowest score was at a good level κ=0.63 (IIb).

To sum up, being aware of the protocol's diagnostic value, authors indicated a need for incorporating imaging of the joint, but only if necessary from the patient's viewpoint or from research problem perspective.

Conclusions

A wide range of diagnostic tools creates a possibility of a multidisciplinary insight into temporomandibular disorders in order to diagnose them correctly.

Helping specialists to select the most valuable techniques shortens the time of the diagnostic process. It is worth noting that some of the techniques or devices may create serious financial consequences for a medical professional or a researcher.

Among all available tools, RDC/TMD protocol seems to be the best choice due to its low cost, clear examination guidelines and classifying algorithms. The unification of result analysis and reasoning allows both researchers and practitioners to compare their findings.

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